

## **Mapping of Land Surface Temperature in Relation to Rainfall in Pasuruan Regency Using Geographic Information System (GIS)**

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### **ABSTRACT**

This study aims to analyze the relationship between Land Surface Temperature (LST) and rainfall in Pasuruan Regency by utilizing Geographic Information System (GIS) technology. Surface temperature data were obtained from Landsat 8 Band 10 satellite imagery, which was converted into temperature in both Kelvin and Celsius, while rainfall data were collected from 20 observation stations distributed across the region. The analysis results indicate a negative correlation between land surface temperature and rainfall, particularly in high-elevation areas that exhibit lower temperatures and higher rainfall. Using the cubic polynomial model algorithm  $y = -3E-09x^3 + 2E-05x^2 - 0.0272x + 43.296$ , the resulting correlation coefficient is 0.2762. This value falls within the interval of 0.20–0.40, which indicates a weak relationship between rainfall and land surface temperature. Rainfall, as variable X, contributes 27.62% to land surface temperature, which acts as variable Y. GIS has proven effective in visualizing the spatial distribution of temperature and rainfall data, providing valuable insights for spatial planning and climate change mitigation in tropical regions.

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### **INTRODUCTION**

Pasuruan Regency, located in East Java Province, Indonesia, has a diverse topography ranging from lowlands to mountainous regions (Baiezt & Barliana, 2024). This variation in elevation influences the distribution of temperature and rainfall across the area. In the context of global climate change, understanding the relationship between land surface temperature (LST) and rainfall is essential for spatial planning and sustainable natural resource management.

Land surface temperature (LST) is a crucial parameter in climatology and environmental studies, as it affects hydrological processes and ecosystems. LST has a direct impact on the distribution and intensity of rainfall in tropical regions (Gede et al., 2020). Changes in LST may influence rainfall patterns through mechanisms such as evapotranspiration and cloud formation. Therefore, analyzing the relationship between LST and rainfall can provide insight into local climate dynamics. Climate fluctuations in East Java over the past decade have shown a rising temperature trend and increasingly erratic rainfall (Hidayat, 2019). Annual statistical reports provide an overview of the social and climatic conditions in Pasuruan Regency, including annual rainfall and average temperatures (Rahmawati & Setyaningrum, 2023).

Remote sensing and GIS technology enable efficient spatial data collection and analysis. Landsat 8 Band 10 satellite imagery provides land surface temperature data with adequate spatial resolution, while GIS facilitates the integration and visualization of temperature and rainfall data in thematic maps. Elevation data and geographic conditions for each district in Pasuruan are available in regional statistical publications (Rahmawati & Setyaningrum, 2023).

This study aims to:

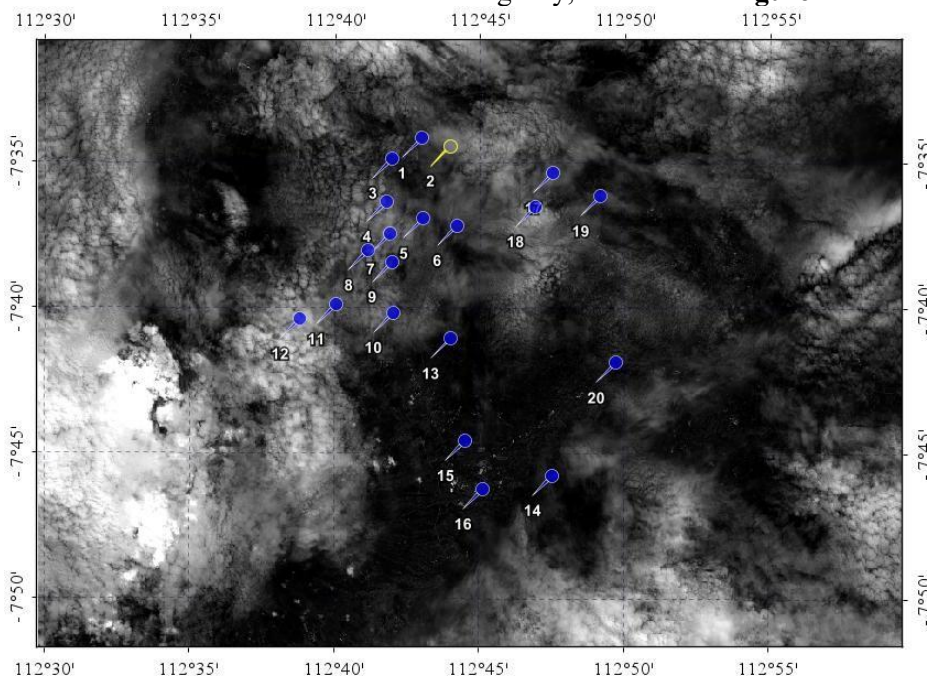
- (1) map the distribution of land surface temperature and rainfall in Pasuruan Regency;
- (2) analyze the spatial relationship between land surface temperature and rainfall using a GIS-based approach; and provide recommendations for regional management based on the analysis results.

### **METHOD**

This study employs a quantitative method by integrating satellite remote sensing data with ground-based climate data. Land Surface Temperature (LST) was extracted from Landsat 8 thermal bands (Band 10 and Band 11), which were downloaded from the USGS Earth Explorer platform. Rainfall data were collected from 20 observation stations distributed across Pasuruan Regency (Rahmawati & Setyaningrum, 2023). Pearson correlation analysis was applied to assess the relationship between LST and rainfall values. Spatial mapping was carried out using GIS software, applying the Inverse Distance Weighting (IDW) interpolation method to visualize temperature and rainfall distribution across the region (Novianti et al., 2021). Radiometric calibration and spectral interpretation were essential for accurate surface temperature estimation (Chander et al., 2009; Lillesand et al., 2015), .

### **Study Area and Data Collection**

Field data collection was necessary to obtain actual data at the study site, which was then correlated with satellite imagery data to derive an appropriate mathematical model. Land surface temperature mapping was related to land use and vegetation cover. Soil surface temperature sampling points were determined directly on-site and taken at locations nearest to the 20 rainfall observation stations across Pasuruan Regency, as shown in **Figure 1**.



**Figure 1.** Study Area Location

Source : Researcher Data, 2025

This figure illustrates the research area located in Pasuruan Regency, East Java, Indonesia. The study area covers both lowland and highland zones, which exhibit varying rainfall and land surface temperature patterns analyzed through Geographic Information System (GIS) techniques.

### **Satellite Data and Parameters Used**

Landsat imagery was utilized to acquire reflectance values, which were then correlated with land surface temperature (LST) values at the study location. Satellite imagery was downloaded from the USGS Earth Explorer website ([earthexplorer.usgs.gov](http://earthexplorer.usgs.gov)), which provides free access to Landsat 8 data. The images were imported into ArcGIS software. The downloaded data included Landsat 8 bands: Band 10, Band 11, Band 4, and Band 5. Temperature extraction from satellite imagery required converting digital numbers (DN) into surface temperature using specific algorithms (Rahmadona et al., 2023).

### **Correlation Analysis**

The relationship between Rrs\_B4 and LST was analyzed using the Pearson correlation method. This analysis aimed to determine the degree of linear relationship between reflectance values and LST in the surface atmosphere. Generally, areas with higher Band 10 and Band (Arif et al., 2019)11 values tend to have higher average surface temperatures, confirming the correlation between thermal radiation measured by these bands and actual surface temperatures(NASA, 2019). Thermal remote sensing is a primary method for studying surface temperature changes in both urban and rural areas(Weng, 2009). During field research, temperature data was collected three times within 15-minute intervals using a digital thermometer. The study was conducted on **Saturday, May 24, 2025**, at the research location.

### **Spatial Mapping**

Mapping was carried out using **Geographic Information System (GIS)** software. GIS serves as a vital tool in spatial analysis, integrating temperature and rainfall data(Novianti et al., 2021). The **Inverse Distance Weighting (IDW)** interpolation method was used to depict the spatial distribution of LST based on coordinates and concentration values. Radiometric calibration of Landsat 8 is crucial for accurate surface temperature calculations(Chander et al., 2009). Interpreting satellite imagery in the context of remote sensing involves understanding spectral channels and

surface temperature (Lillesand et al., 2015). Spatial distribution of temperature and rainfall can be modeled using a combination of satellite data and field climatological data (Arridha et al., 2023).

**RESULT**

In this section, it is explained the results of the research and at the same time is given a comprehensive discussion. Results can be presented in figures, graphs, tables, and others that make the reader understand easily. The discussion can be made in several sub-chapters.

**Data Description**

The presented table contains data from 20 observation posts located in the western part of Indonesia, approximately around 7° South Latitude and 112° East Longitude. Significant variation is observed in average surface temperature among the stations, ranging from 9.01°C in Winong (the coldest post) to 29.11°C in Kiduldalem/Bangil (the hottest post). The decrease in temperature with increasing elevation indicates a strong relationship between land surface temperature and elevation (Tanuwiria et al., 2022).

Land Surface Temperature (LST) data obtained from Landsat 8 exhibited inconsistencies, likely caused by factors such as cloud cover obstructing satellite sensors during data acquisition. Topography and soil conservation practices also influence the distribution of temperature and rainfall patterns (Naharuddin, 2016). Additionally, thermal bands (Band 10 and Band 11) showed variation. Generally, stations with higher values in these bands tended to have higher surface temperatures, confirming the correlation between thermal radiation and actual surface temperature. Changes in LST significantly impact microclimates and local environmental conditions (Jaelani & Handayani, 2022).

In field measurements, temperature data were taken three times within 15-minute intervals using a digital thermometer. The field survey was conducted on Saturday, May 24, at sites near the rainfall stations.

**Table 1.** Comparison of In Situ Temperature and Landsat 8 Satellite-Derived Temperature in Pasuruan Regency

Latitude	Longitude	Spectral Radiance	Average Insitu Temperature (°C)	Landsat 8 Average Temperature (°C)
07 ° 34 ' 50.70 "	112 ° 42 ' 18.10 "	7.4283376	29.8	<b>9.01</b>
07 ° 25 ' 06.80 "	112 ° 43 ' 17.00 "	9.7212838	29.9	<b>26.43</b>
07 ° 35 ' 32.30 "	112 ° 41 ' 17.40 "	8.660533	29.7	<b>20.44</b>
07 ° 37 ' 06.90 "	112 ° 41 ' 06.10 "	8.3925046	<b>25.5</b>	19.09
07 ° 37 ' 36.40 "	112 ° 42 ' 22.20 "	7.6993738	24.6	<b>11.41</b>
07 ° 37 ' 51.50 "	112 ° 43 ' 31.80 "	7.5339448	25.2	<b>10.21</b>
07 ° 38 ' 17.20 "	112 ° 41 ' 11.60 "	7.7468302	24.2	<b>11.73</b>
07 ° 38.42.20 "	112 ° 40 ' 28.50 "	7.7752372	<b>23.9</b>	11.85
07 ° 39 ' 06.70 "	112 ° 41 ' 17.60 "	9.3493192	24.1	<b>23.21</b>
07 ° 40 ' 43.60 "	112 ° 41 ' 50.60 "	8.5355422	29.9	<b>19.1</b>
07 ° 40 ' 34.40 "	112 ° 59 ' 22.50 "	9.3997834	23.9	<b>24.48</b>
07 ° 41 ' 07.80 "	112 ° 38 ' 06.60 "	9.9532186	<b>22.2</b>	27.63
07 ° 41 ' 44.70 "	112 ° 43 ' 20.00 "	7.7769082	23.9	<b>11.77</b>
07° 43' 03.20"	112° 04' 03.50"	8.9268904	29.8	<b>22.53</b>
07 ° 45' 14.60 "	112 ° 43 ' 50.55 "	9.0154534	23.6	<b>22.76</b>
07 ° 46' 54.40 "	112° 44' 27.60"	9.1708564	<b>23.5</b>	23.26
07 ° 36 ' 01.90 "	112 ° 46 ' 50.20 "	10.117645	29.8	<b>29.11</b>
07 ° 37 ' 11.20 "	112 ° 46 ' 13.20 "	8.9710048	29.8	<b>22.85</b>
07 ° 36 ' 49.30 "	112 ° 48' 28.40 "	9.8967388	29.8	<b>27.7</b>
<b>07° 42' 33.30"</b>	<b>112° 49' 02.50 "</b>	<b>6.8030494</b>	27.1	15.92

Explanation: A = Data To Be Validated

Source : Researcher Data, 2025

This table presents a comparison between field-measured (in situ) land surface temperatures and those derived from Landsat 8 satellite imagery. The temperature differences highlight the influence of topography and land cover on the accuracy of satellite-based temperature estimation.

**Table 2.** T-test of In Situ Temperature vs. Landsat 8 Satellite Image Temperature

	<i>Insitu Temperature</i>	<i>Landsat 8</i>
<b>Mean</b>	27.2	<b>19.516</b>
<b>Variance</b>	8.481428571	<b>47.15502571</b>
<b>Observations</b>	15	<b>15</b>
<b>Pooled Variance</b>	27.81822714	

	Insitu Temperature	Landsat 8
Hypothesized Mean Difference	0	
df	28	
t Stat	<b>3.989819636</b>	
P(T<=t) one-tail	0.000215916	
t Critical one-tail	<b>1.701130934</b>	
P(T<=t) two-tail	0.000431832	
t Critical two-tail	<b>2.048407142</b>	

Source : Researcher Data, 2025

This table shows the results of the *t-test* statistical analysis comparing in situ temperature data with satellite-derived temperature data from Landsat 8. The calculated *t-value* exceeds the critical *t-table* value, indicating a statistically significant difference between the two measurement methods.

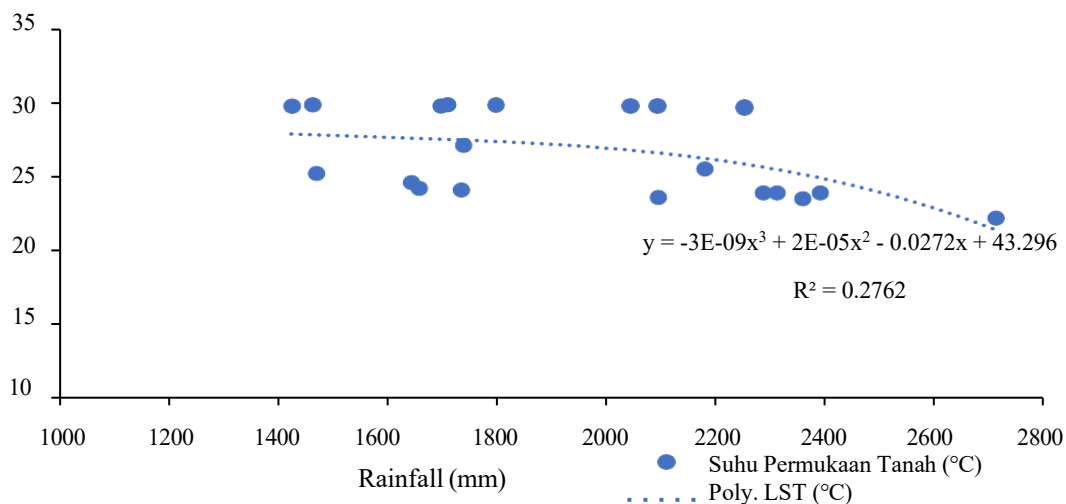
**Hypothesis:**

H<sub>1</sub> is accepted, since  $t_{\text{calculated}} > t_{\text{table}}$   $t_{\text{calculated}} = 3.989819636 > t_{\text{table}} = 1.701130934$

The result of the **T-test** indicates a significant difference between in-situ temperature and Landsat 8-derived temperature, validating the hypothesis.

**Relationship Between Rainfall and Land Surface Temperature**

Based on the summary of rainfall–LST algorithm models, the highest correlation (R) was obtained using a cubic polynomial model:  $y = -3E-09x^3 + 2E-05x^2 - 0.0272x + 43.296$  This model yields a correlation coefficient of **0.2762**, which falls within the **0.20–0.40 interval**, indicating a **weak relationship** between rainfall and land surface temperature.



**Figure 2.** Polynomial Scatter Plot: Land Surface Temperature vs. Rainfall

Source : Researcher Data, 2025

This figure presents a scatter plot showing the relationship between land surface temperature (LST) and rainfall using a cubic polynomial model. The downward trend indicates a negative correlation, suggesting that areas with higher rainfall tend to have lower land surface temperatures.

To determine the coefficient of determination ( $R^2$ ), the following formula was used:

$$R^2 \times 100\% = 0.2762 \times 100\% = 27.62\%$$

This means that rainfall (variable X) contributes **27.62%** to variations in land surface temperature (variable Y).

**Table 3.** Summary of Rainfall – Land Surface Temperature Algorithm

No	Algorithm	Model	R2
1	Linear	$y = -0.0038x + 33.947$	<b>0.2266</b>
2	Exponential	$y = 35.13e^{-1E-04x}$	<b>0.2389</b>

No	Algorithm	Model	R2
3	Logarithm	$y = -7.123\ln(x) + 80.372$	<b>0.2090</b>
4	Power	$y = 210.5x^{-0.275}$	<b>0.2198</b>
5	Polinom. Quadratic	$y = -5E-06x^2 + 0.0156x + 15.144$	<b>0.2723</b>
6	Polinom. Cubic	$y = -3E-09x^3 + 2E-05x^2 - 0.0272x + 43.296$	0.2762

Source : Researcher Data, 2025

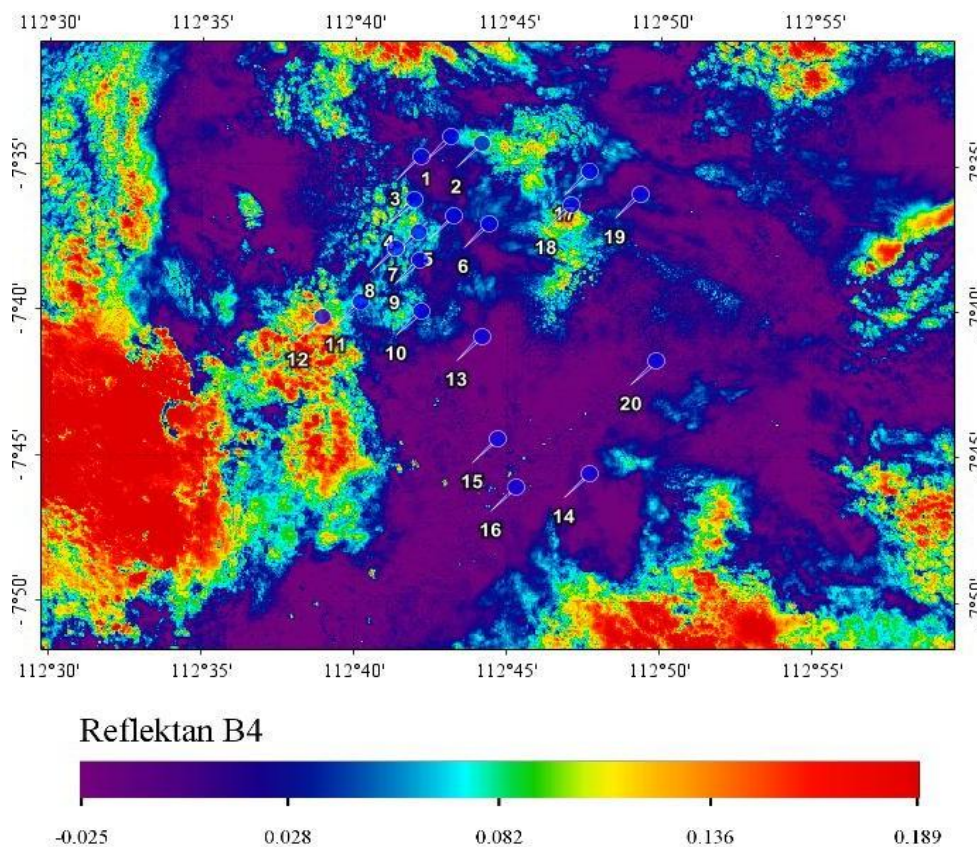
This table summarizes various algorithmic models used to analyze the relationship between rainfall and land surface temperature. The cubic polynomial model produced the highest correlation coefficient ( $R^2 = 0.2762$ ), representing a weak but measurable relationship between the two variables.

### Spatial Mapping

Spatial analysis reveals temperature variations (in °C) across 20 different stations. The lowest recorded temperature was **22.2°C** in Prigen, while the highest reached **29.9°C** in Ketanireng/Wilo and Mojoparon/Badong, indicating a temperature range of **7.7°C**. Most locations recorded temperatures above 23°C.

Several areas such as Winong/Gempol, Gununggangsir/Banyulegi, Ketanireng/Wilo, Nguling Sedarum, Kiduldalem/Bangil, Kalusari/Bekacak, and Mojoparon/Badong registered relatively high temperatures nearing or exceeding 29°C.

### 1. Band 4



**Figure 3.** Landsat 8 Band 4 Reflectance

This figure displays the reflectance of Band 4 from Landsat 8 satellite imagery, representing the visible red wavelength used to assess vegetation and land cover conditions across Pasuruan Regency.

## 2. Band 10

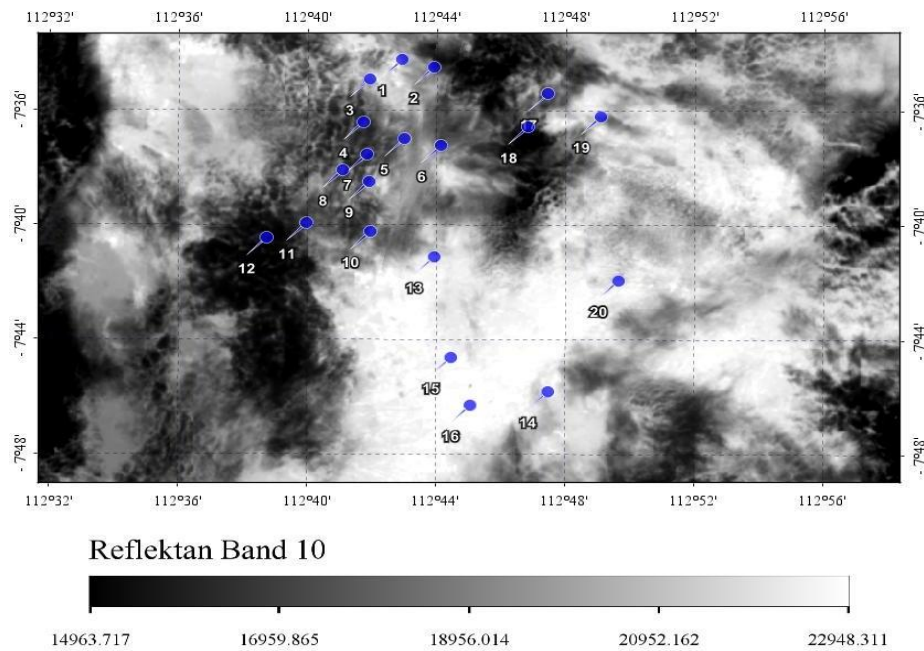


Figure 4. Landsat 8 Band 10 Reflectance

This figure shows the reflectance of Band 10 from Landsat 8 imagery, which captures the thermal infrared wavelength used for estimating land surface temperature. Higher reflectance values indicate areas emitting greater thermal radiation.

## 3. Rainfall Map

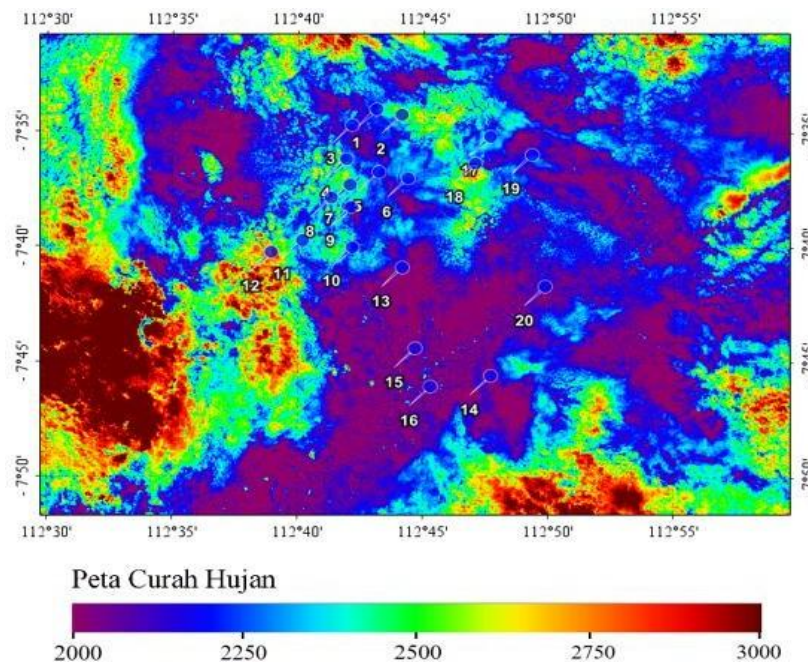
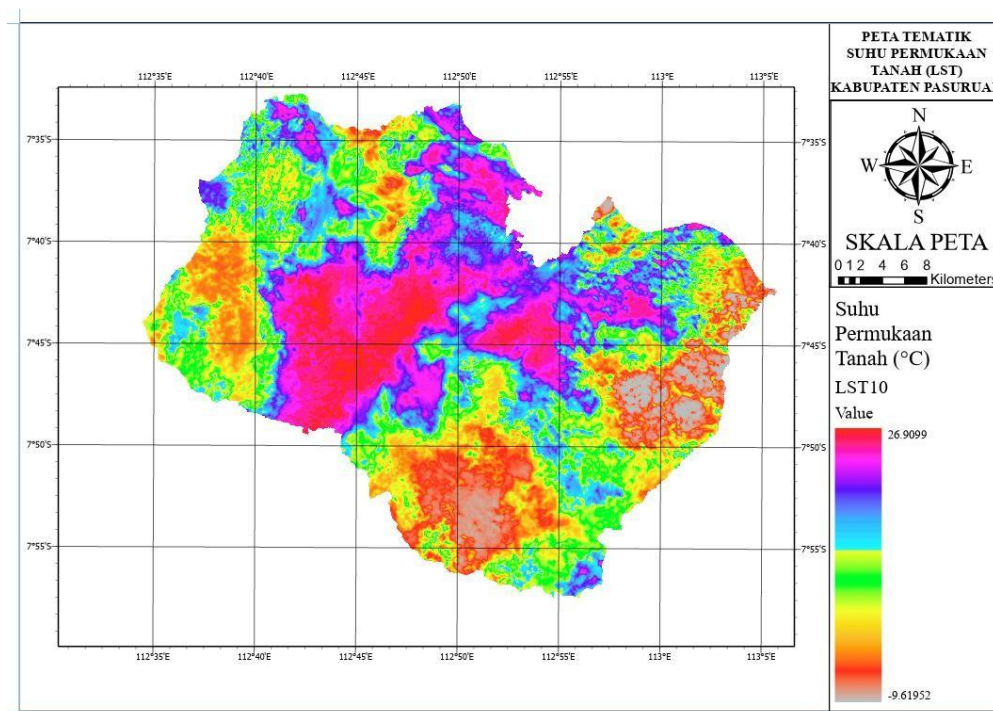


Figure 5. Rainfall Map

Source : Researcher Data, 2025

This map visualizes the spatial distribution of rainfall across Pasuruan Regency. Darker shades represent higher rainfall intensity, primarily concentrated in the southern highland regions, while lighter areas indicate lower precipitation levels.

#### 4. Original Thematic Map Of Land Surface Temperature Based On Landsat 8 Band 10 Satellite Imagery



**Figure 6.** Original Thematic Map Of Land Surface Temperature Based On Landsat 8 Band 10 Satellite Imagery  
Source : Researcher Data, 2025

This figure presents the thematic land surface temperature (LST) map generated from Landsat 8 Band 10 data. Red-colored zones indicate higher surface temperatures found in lowland areas, whereas blue zones correspond to cooler temperatures in elevated and vegetated regions.

#### Correlation and Implications

The analysis shows a **negative correlation** between land surface temperature and rainfall in Pasuruan Regency. Areas with high surface temperatures tend to receive lower rainfall, while regions with lower temperatures (usually highland or vegetated areas) receive higher rainfall.

Climatologically, this phenomenon can be explained through **evapotranspiration and cloud formation**. Areas with lower temperatures and high humidity are more favorable for cloud formation and precipitation, while hot, dry areas are more prone to drought.

#### Implications:

##### 1. Spatial and Regional Planning (RTRW):

Spatial information on temperature and rainfall can assist local governments in designing agricultural, forestry, and development zoning—particularly for drought and flood mitigation planning.

##### 2. Climate Mitigation and Adaptation:

The relationship between temperature and rainfall can support the formulation of local climate strategies, such as reforestation, water management, and land conservation.

##### 3. Food and Agricultural Security:

Farmers in regions with high surface temperatures and low rainfall face a higher risk of crop failure. This information is useful for preparing planting calendars and selecting suitable crops.

##### 4. Infrastructure Development:

Regions with high temperatures and low rainfall are more vulnerable to **urban heat island** effects and water shortages. Therefore, water infrastructure development and urban greening should be prioritized.

#### CONCLUSION

This study concludes that there is a significant negative correlation between land surface temperature and rainfall in Pasuruan Regency. Areas with low elevation and built-up land use tend to have higher surface temperatures and lower

rainfall levels. In contrast, regions with higher elevation and dense vegetation cover exhibit lower temperatures and higher rainfall.

The use of Geographic Information System (GIS) has proven highly effective in performing spatial analysis of these climatological parameters, offering a more comprehensive understanding of the spatial relationship between temperature and rainfall.

Therefore, the findings of this study are valuable as a basis for decision-making in regional planning, agriculture, water resource management, and strategies for climate change mitigation and adaptation.

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